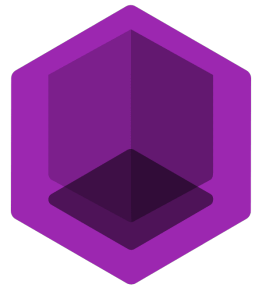
“The Inner Workings of VICKY II”

A 2D Graphics Engine
For New Retro Computers

VCF EAST 2022

April 2022

FRIDAY CLASS



FOENIX RETRO SYSTEMS

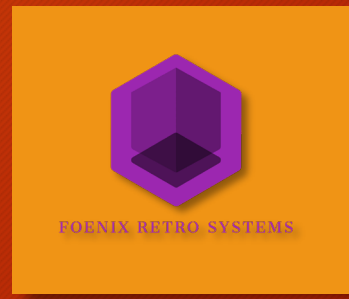
VCF EAST 2022 – FRIDAY CLASS AGENDA

- Introduction (8minutes)
  - Self Introduction – My Background
  - Assumption of the level of knowledge
- VICKY II (~40 minutes)
  - Recap: How does a video controller work
  - VICKY II – External Interface (VDAC & Vmemory)
  - Internal VICKY II Block Diagram
  - The Layering system
  - The bitmap State Machine summary
  - The Tile State Machine summary
  - The Sprite State Machine summary
  - How the memory bandwidth is utilized
- Recap
  - Questions?

INTRODUCTION – WHO IS STEFANY? – MY BACKGROUND (1/2)

- My father bought a C64 in late 1982 at full price - Introduction to computers. (I am old you know)
- I began doing electronic @ 13 when playing with my brother's Radio Shack lab kit 75 in 1
- Done a lot of electronic hacking during my teenage years (didn't go out much… I still don't)
- Began my career as electronic Technician to repair computers then repair instrumentations.
- Within a year, I was promoted in the Engineering department; a year later I was responsible to develop a new product.
- Started my first company in 1996 (Failed) – Create a card to accelerate the Geometry processing for 3D Rendering – The goal was to faster rendering to do VR. (VR is not a new thing by the way, it is like Stereoscopy for cinema, it is a fad, it comes and it goes)
- Started my second company in 1998 (Failed) – Technology was developing too fast, it was too little too late.
- Went in technical sales – Loved helping people, hated the politics of it. (The greed)
- Went to work for many companies as hardware/system developer.

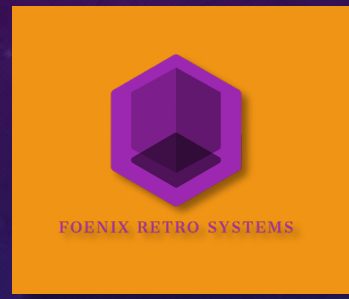
INTRODUCTION – WHO IS STEFANY? – MY BACKGROUND (2/2)



- Started my third company in 2004 (Eventually Failed) – It just lasted longer. But the foundations were fragile. At that point it was about parallel processing then Global shutter Camera.
- Back from LA in 2013, go back to work for others.
- Finally, without really wanting to begin a new company again, here it is Foenix Retro Systems. The company I never wanted to start.
- This is the Universe for you, all those years I wanted to start a company and I failed and when I don't want it anymore if just spat me in the face and it is like I have no choice.

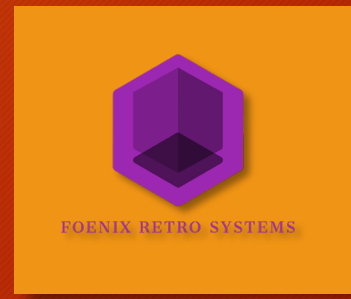
The moral of the story is that it is really all the failures that got me to learn so much about Product design/FPGA Design and mechanical design and of course programming and human nature. Now, the good side of this is that it makes me somebody who is very versatile, but the counter effect is that I can't be a pro at anything. At every level, there are people far better than me.
The other moral is that when you let go of something, it comes back to you. (if it meant to be… of course)

INTRODUCTION – THE ASSUMPTIONS (PRE-REQUISITES)

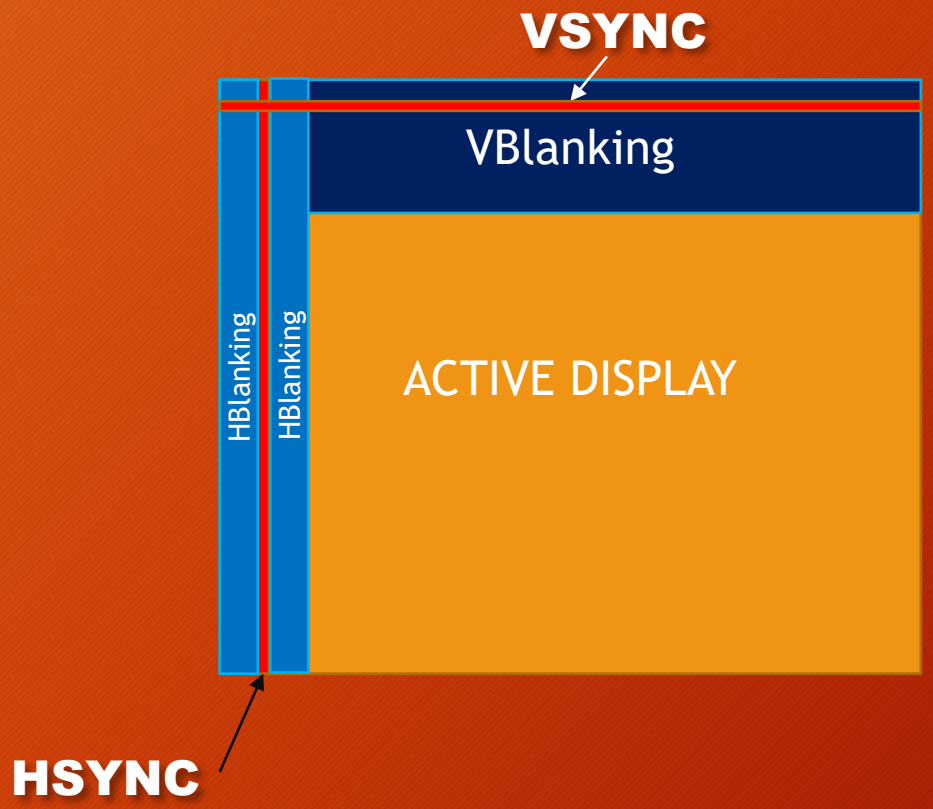


- There are no real pre-requisite this year.
- Being technically savvy will help, but it is mostly about structure and how the pixel data is moved around.

RECAP - How a display works

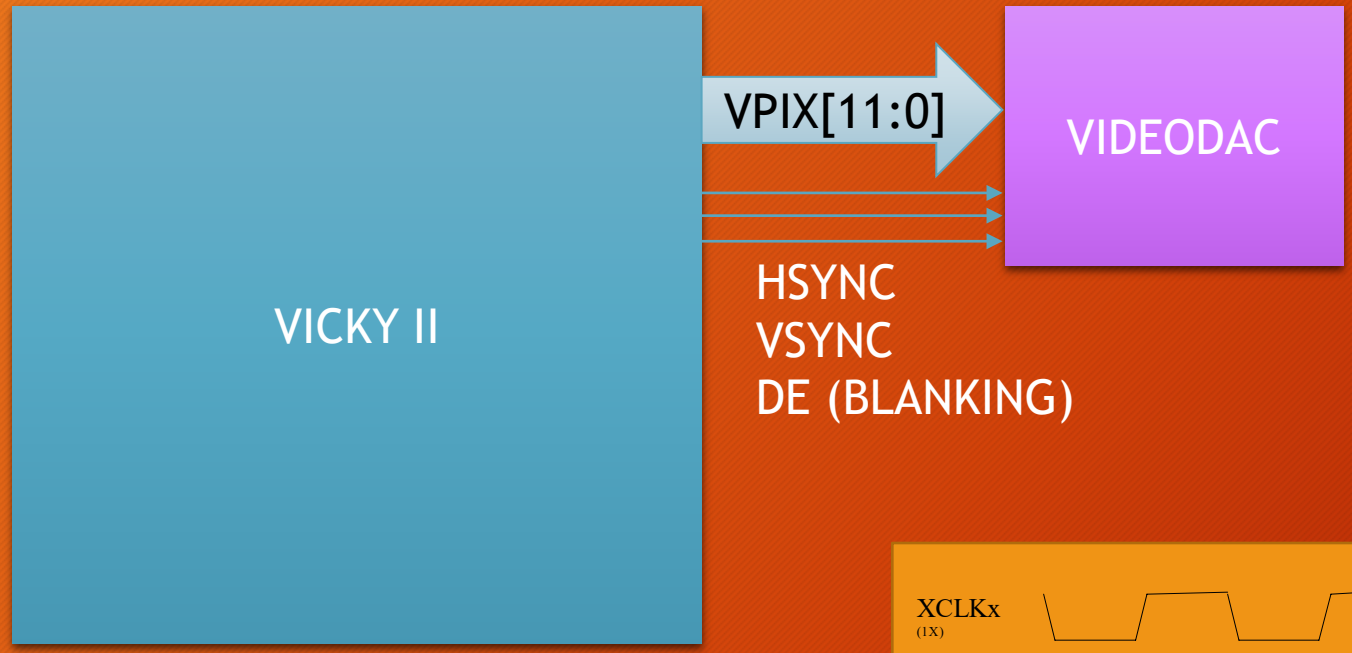


2D View of Displayed image with ancillary signals



Tinyvga.com (for timing information)

VICKY II - INTERFACE IN THE SYSTEM (1/2) - VDAC



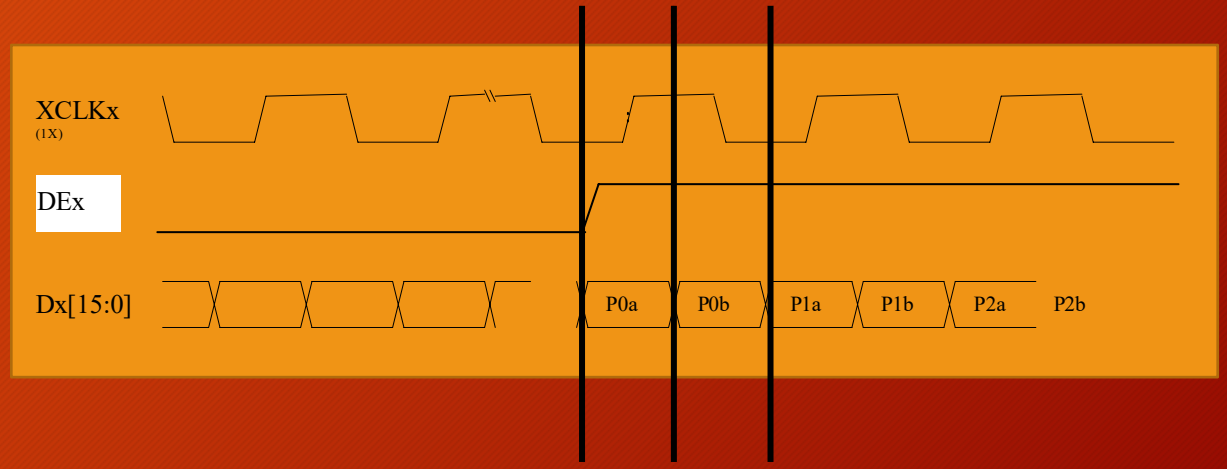
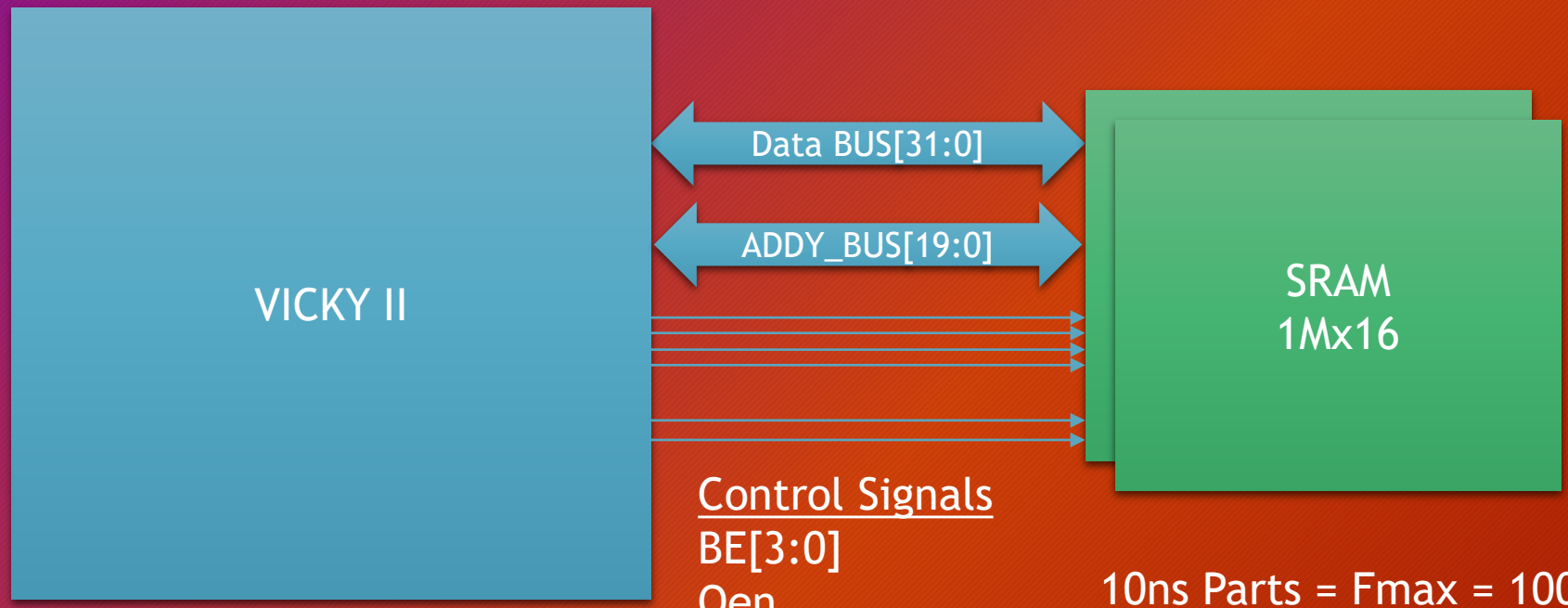


Table 6: Multiplexed Input Data Formats (IDF = 0, 1)

IDF =		0				1			
Format =		12-bit RGB				12-bit RGB			
Pixel #		P0a	P0b	P1a	P1b	P0a	P0b	P1a	P1b
Bus Data	D[11]	G0[3]	R0[7]	G1[3]	R1[7]	G0[4]	R0[7]	G1[4]	R1[7]
	D[10]	G0[2]	R0[6]	G1[2]	R1[6]	G0[3]	R0[6]	G1[3]	R1[6]
	D[9]	G0[1]	R0[5]	G1[1]	R1[5]	G0[2]	R0[5]	G1[2]	R1[5]
	D[8]	G0[0]	R0[4]	G1[0]	R1[4]	B0[7]	R0[4]	B1[7]	R1[4]
	D[7]	B0[7]	R0[3]	B1[7]	R1[3]	B0[6]	R0[3]	B1[6]	R1[3]
	D[6]	B0[6]	R0[2]	B1[6]	R1[2]	B0[5]	G0[7]	B1[5]	G1[7]
	D[5]	B0[5]	R0[1]	B1[5]	R1[1]	B0[4]	G0[6]	B1[4]	G1[6]
	D[4]	B0[4]	R0[0]	B1[4]	R1[0]	B0[3]	G0[5]	B1[3]	G1[5]
	D[3]	B0[3]	G0[7]	B1[3]	G1[7]	G0[0]	R0[2]	G1[0]	R1[2]
	D[2]	B0[2]	G0[6]	B1[2]	G1[6]	B0[2]	R0[1]	B1[2]	R1[1]
	D[1]	B0[1]	G0[5]	B1[1]	G1[5]	B0[1]	R0[0]	B1[1]	R1[0]
	D[0]	B0[0]	G0[4]	B1[0]	G1[4]	B0[0]	G0[1]	B1[0]	G1[1]

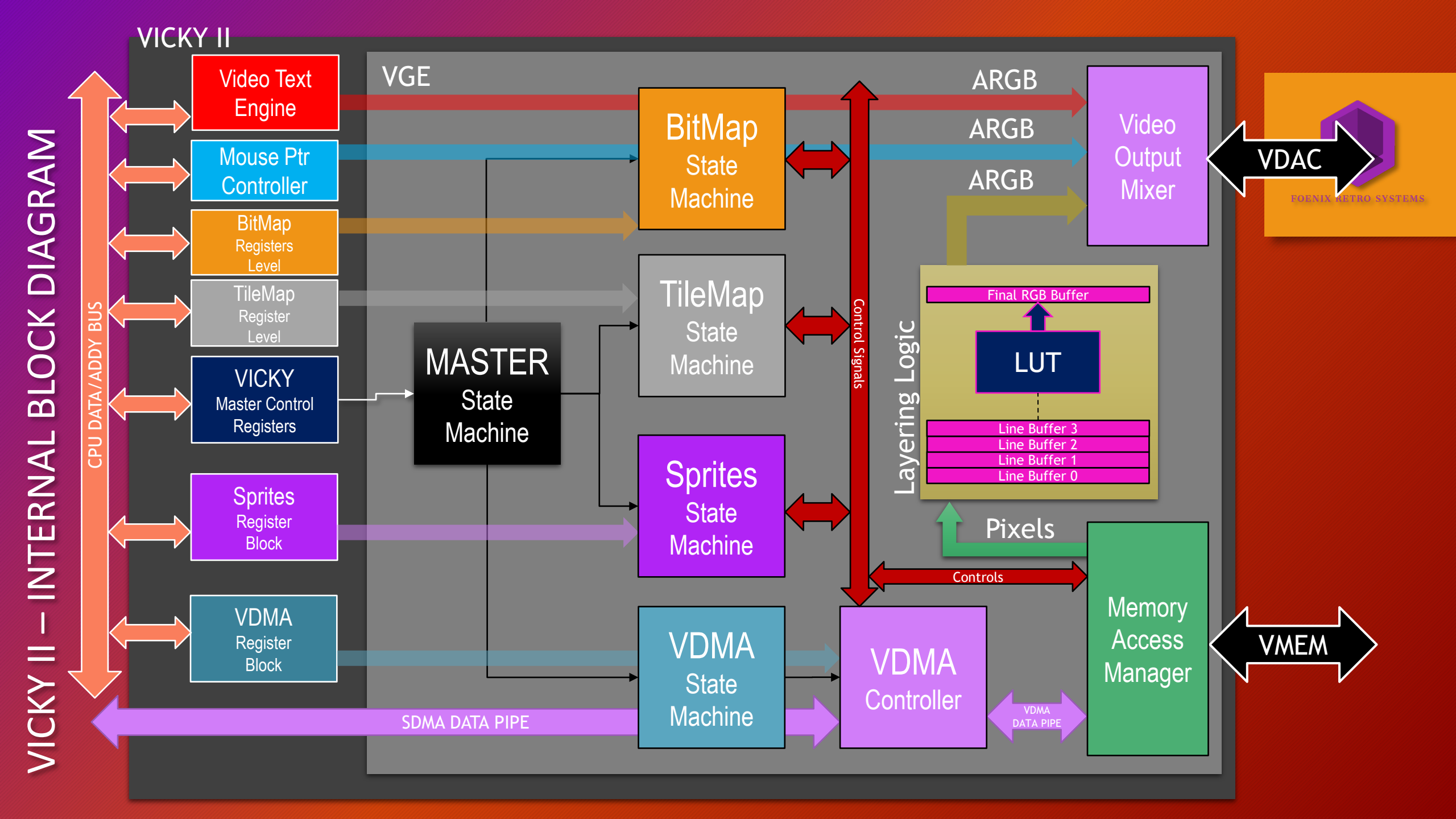
VICKY II - INTERFACE IN THE SYSTEM (2/2) – VMEM (SRAM)



Control Signals
BE[3:0]
Oen
WEn

10ns Parts = Fmax = 100Mhz
32bits = 4 Bytes
Max Throughput: 400MBytes/Sec

Why SRAM instead of Cheaper SDRAM


VICKY II – INTERNAL BLOCK DIAGRAM
VICKY II
CPU DATA/ADDY BUS
Video Text Engine
Mouse Ptr Controller
BitMap Registers Level
TileMap Register Level
VICKY Master Control Registers
Sprites Register Block
VDMA Register Block
VGE
MASTER State Machine
BitMap State Machine
TileMap State Machine
Sprites State Machine
VDMA State Machine
SDMA DATA PIPE
Control Signals
ARGB
ARGB
ARGB
Video Output Mixer
VDAC
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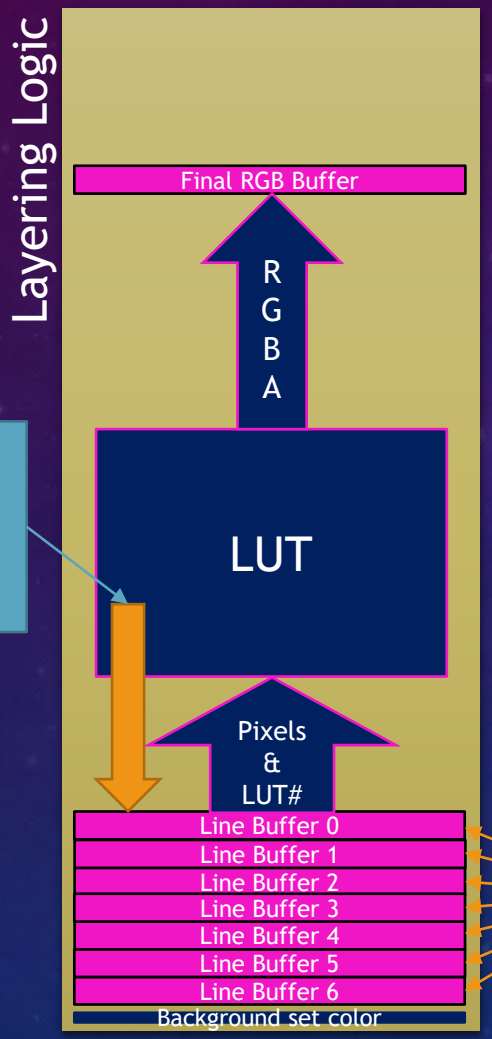
Layering Logic
Final RGB Buffer
LUT
Line Buffer 3
Line Buffer 2
Line Buffer 1
Line Buffer 0
Pixels
Controls
VDMA Controller
VDMA DATA PIPE
Memory Access Manager
VMEM

VICKY II – THE LAYERING LOGIC

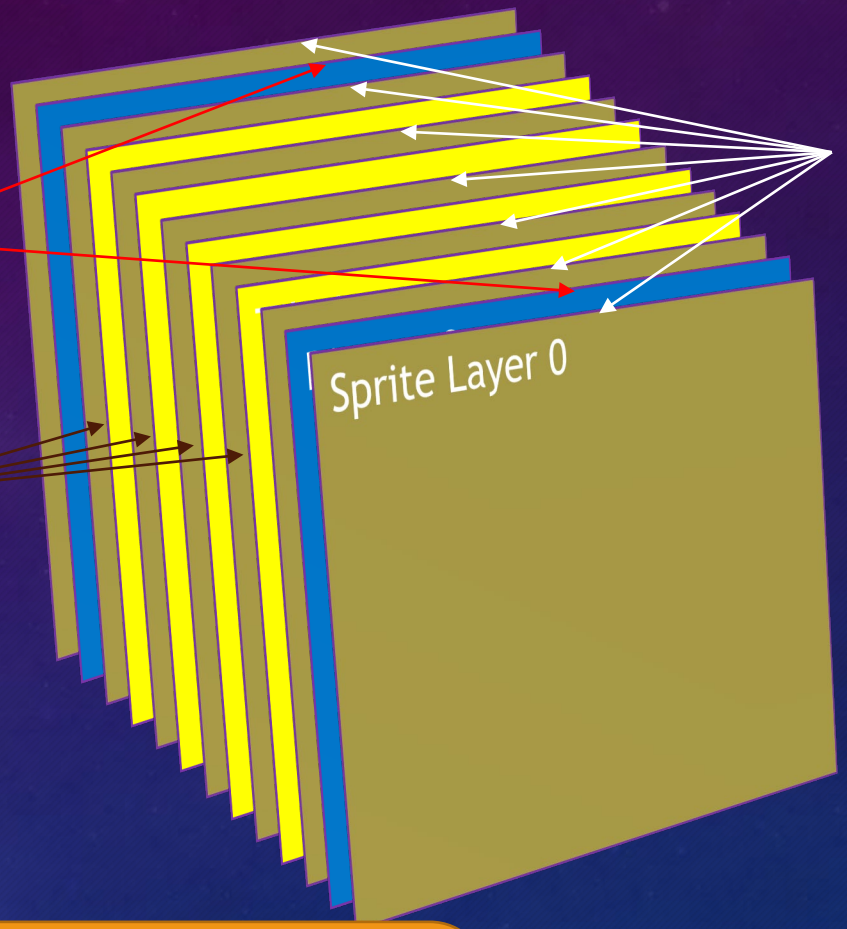


The direction
The logic find
the pixel to
display

Layers Stack-up

Bitmap Layers

TileMap Layers



Sprite Layers

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Line Buffers
Are by their nature a form of
Priority management
Considering that Pixel with
Value 0 is transparent.

VICKY II – BITMAP STATE MACHINE

Bitmap
State Machine

The Concept behind **Bitmap**
Is very simple because we simply fetch directly the data from VRAM and store it in a line buffer in the layering logic.

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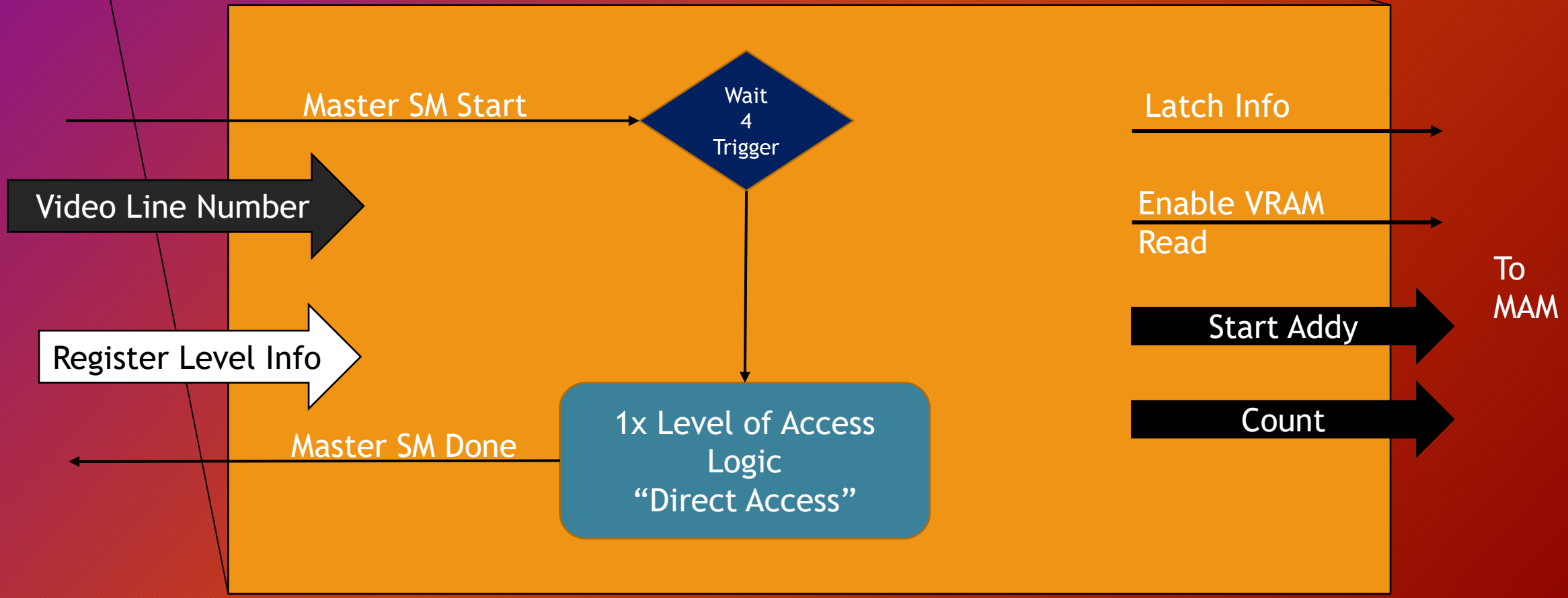
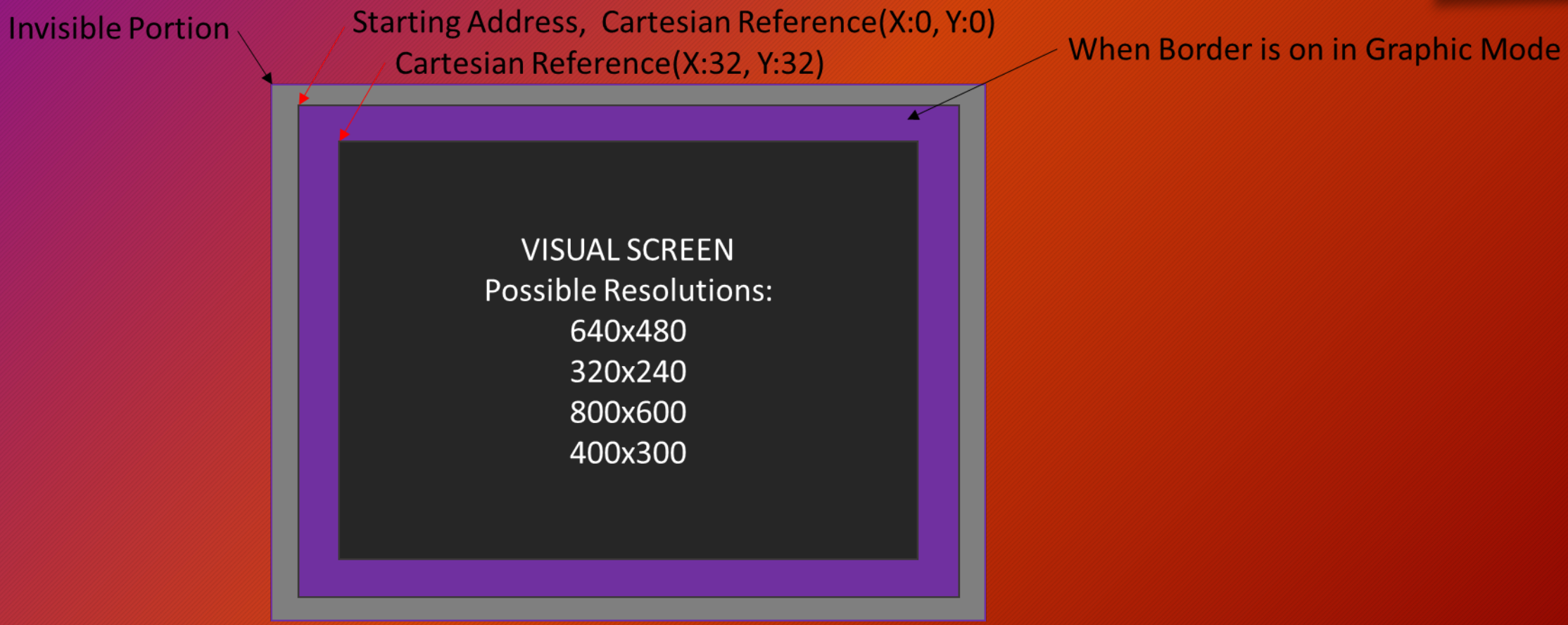


Bitmap Layers – Normal Mode



VICKY II – TILEMAP STATE MACHINE

TileMap
State Machine

The Concept behind **Tilemap** is somewhat more complex, it requires 2 level of access.
1- Fetch the Tile Number information needed
2- Fetch the Graphics element of that tile
Tiles are like FONTs but bigger.

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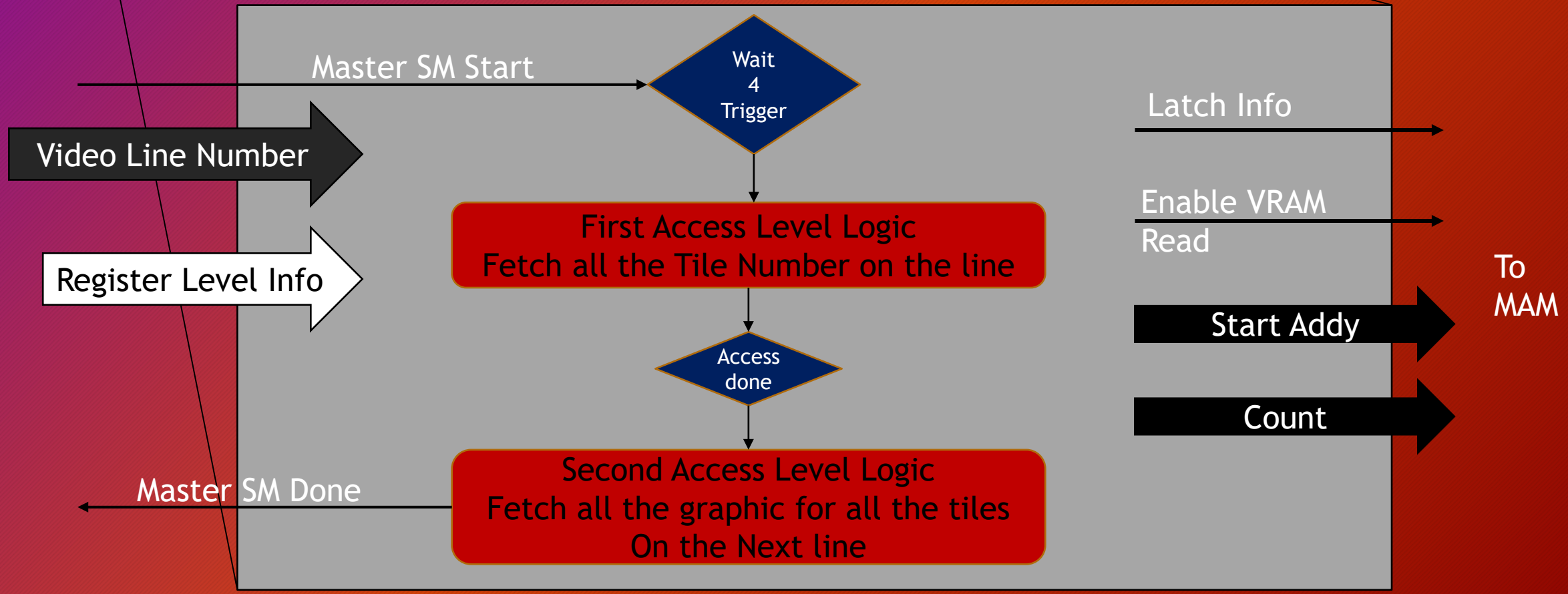
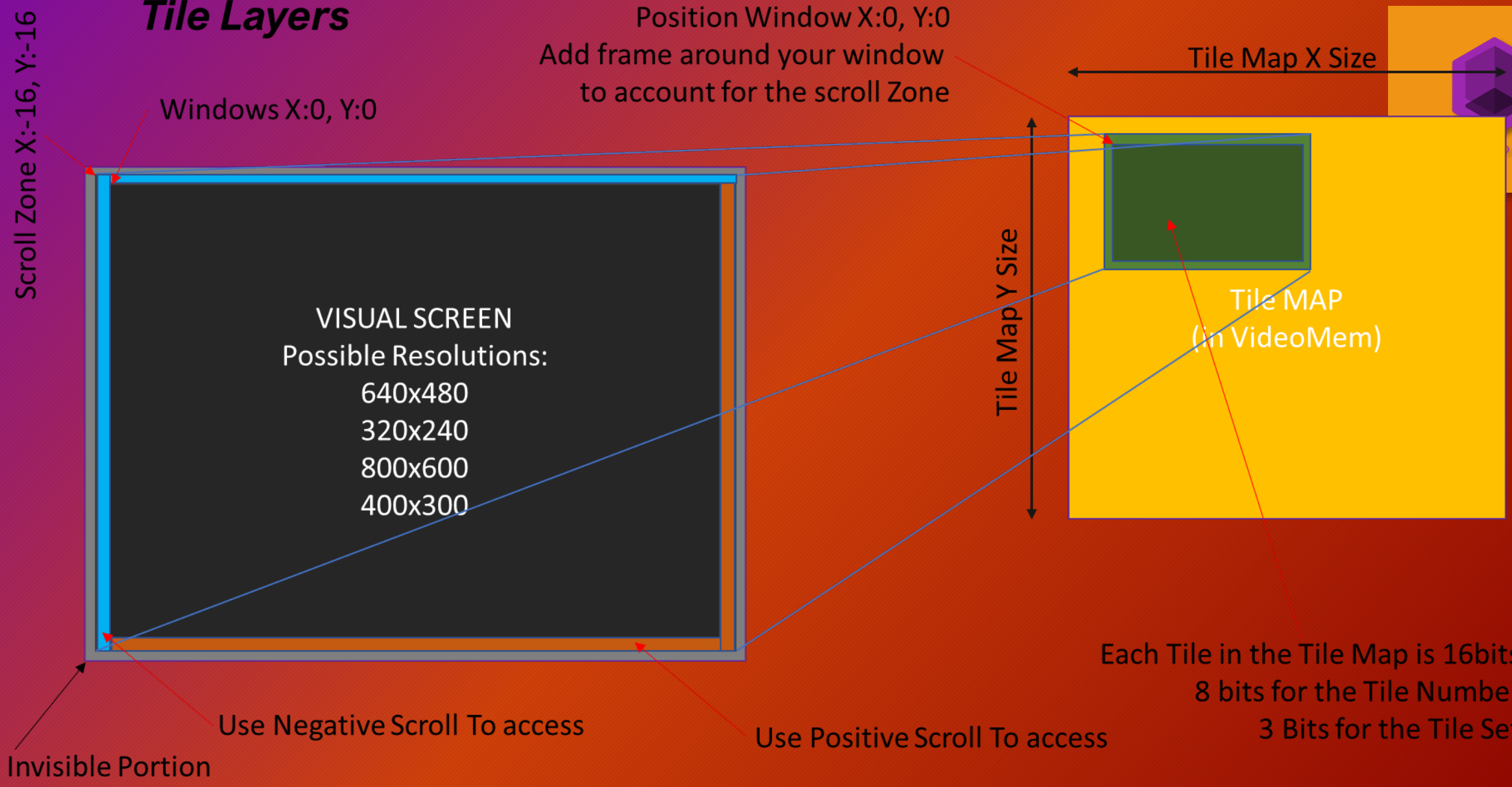


Tile Layers


Scroll Zone X:-16, Y:-16
Windows X:0, Y:0
Position Window X:0, Y:0
Add frame around your window
to account for the scroll Zone
Tile Map X Size
Tile Map Y Size
VISUAL SCREEN
Possible Resolutions:
640x480
320x240
800x600
400x300
Tile MAP
(in VideoMem)
Each Tile in the Tile Map is 16bits
8 bits for the Tile Number
3 Bits for the Tile Set
Use Negative Scroll To access
Use Positive Scroll To access
Invisible Portion

VICKY II – SPRITES STATE MACHINE

Sprites
State Machine

The Concept behind **Sprites** is quite different from the other 2 concepts because we need 1 small block data that is placed anywhere on the screen. So we need to fetch data from VRAM then save it, then position it on the Line Buffer.

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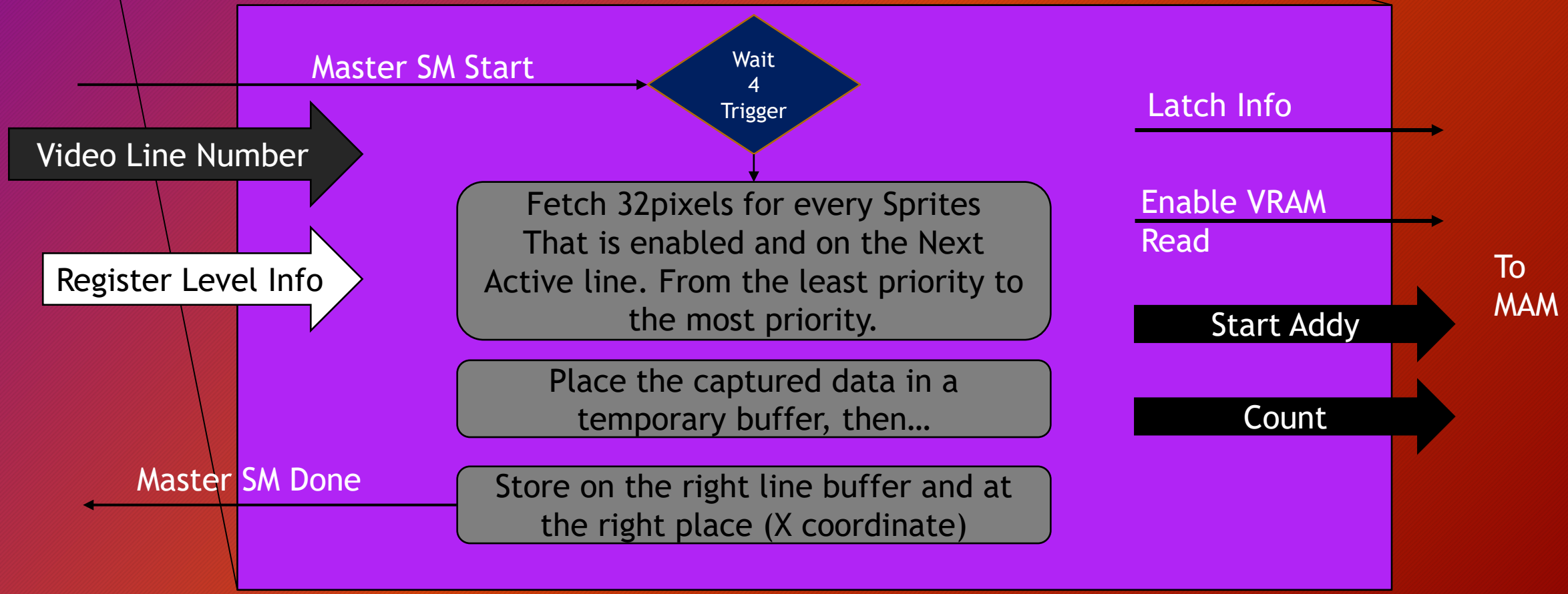
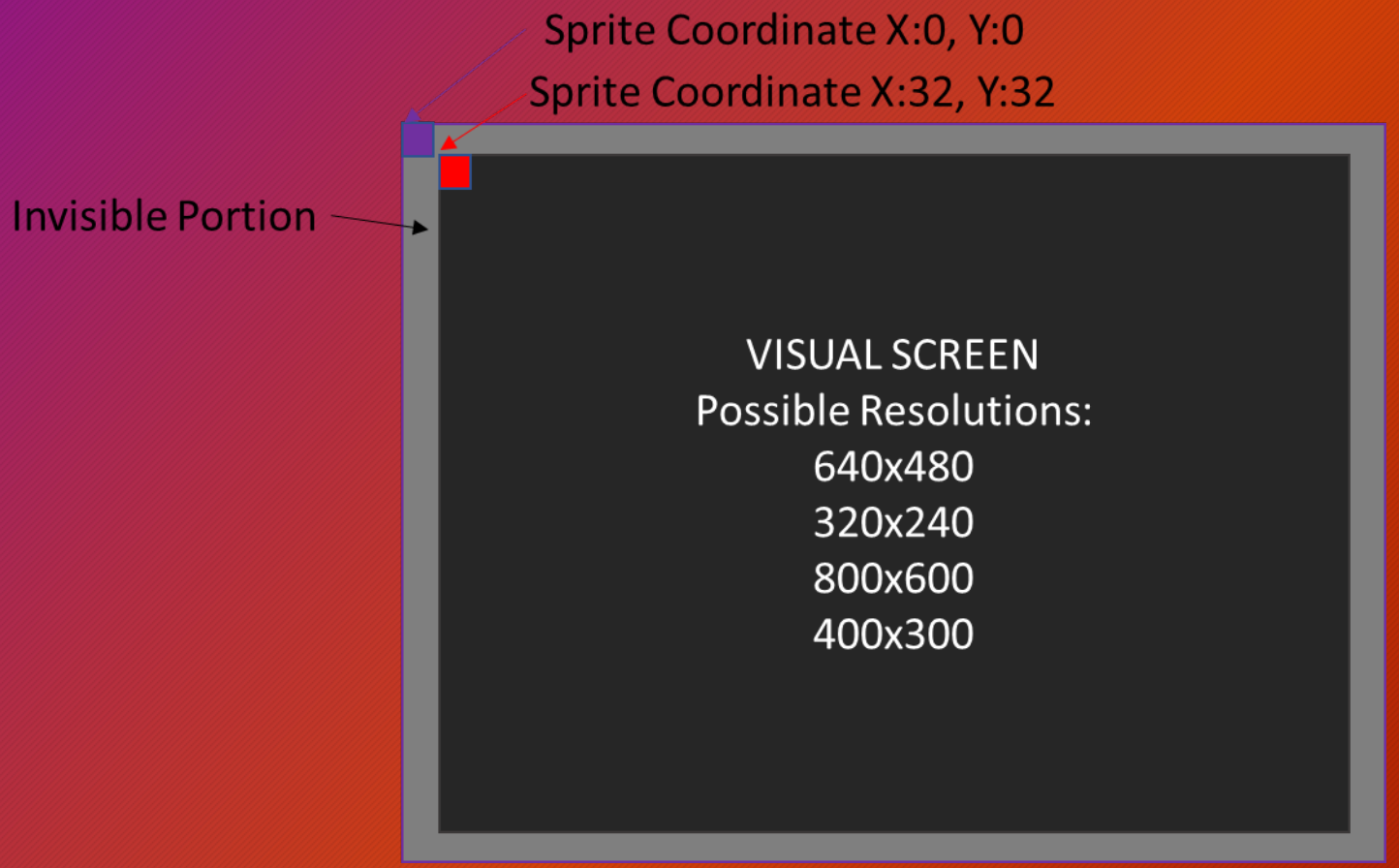


Sprites



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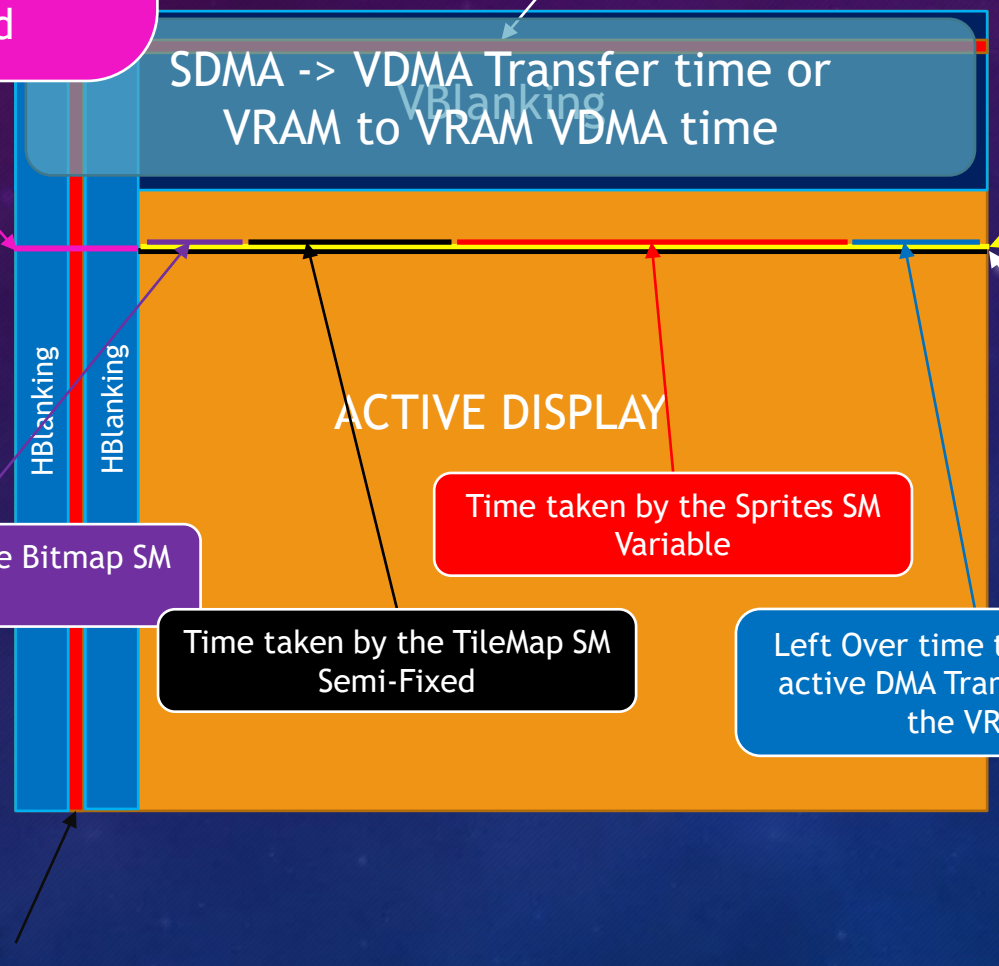
HOW THE MEMORY BANDWIDTH IS USED

IT IS ALL ABOUT HOW MUCH DATA YOU CAN READ & WRITE
IN THE ALLOWED TIME.

The Line buffers
Are processed,
Prioritized and pass
through the LUT
Then Stored in the Final
ARGB Line Buffer Ready
to be displayed



Time where data is being
read from VRAM
To be stored in each line
buffer that
Represents a Layer
This is the time where the
Different State Machine are
active
To fetch their respective
pixel data, one after the
other

RGB Data being
displayed from the
Final Line Buffer

QUESTIONS ?

THANK YOU!

Thanks to the VCF Community and especially **Jeffrey Brace**!

WWW.C256FOENIX.COM

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